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U. S. COAST AND GEODETIC SURVEY

E. LESTER JONES

SUPERINTENDENT

HYDROGRAPHY

WIRE-DRAG WORK ON THE ATLANTIC COAST

BY

N. H. HECK and J. H. HAWLEY

Assistants

SPECIAL PUBLICATION No. 29

WASHINGTON

GOVERNMENT PRINTING OFFICE

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WIRE-DRAG WORK ON THE ATLANTIC COAST.

By N. H. Heck and J. H. Hawley, *Assistants.*

INTRODUCTORY.

The eastern coast of the United States was the first to be navigated and the number, size, and draft of the vessels using its channels and harbors have steadily increased. Surveys of its waters have been in progress for many years, and accurate surveys, by the best hydrographic methods, have been carried on since the early seventies. Even now, however, vessels occasionally strike uncharted rocks, and the average person will fail to understand how this is possible and why the Coast and Geodetic Survey, unless it has been very negligent, should be obliged to make a resurvey of all the rocky portions of the coast in order to insure the safety of vessels. This is not to be explained by any lack of zeal or care on the part of the many men who have been engaged on the work. There has been an undoubted tendency, in the past, to place too great a reliance on the universal method for making hydrographic surveys (that of using a lead line from a moving vessel) for the reason that, until the wire drag was perfected, it was the only practical method known. This method is excellent for getting the general depth and contour of the bottom, and, in moderate depths of water, remains the only satisfactory means of getting this data. With proper precautions it is the only method necessary on the sandy portions of the coast, but, on rocky coasts, it must be supplemented by some means for finding pinnacle rocks, sharp ledges, and bowlders.

For the greater part of the New England coast nature has not been so accommodating as to make the underwater areas very different from the adjoining land areas. For example, Diamond Rock, which projects about 40 feet above the water in East Penobscot Bay, with the small extent and very steep sides of a true pinnacle rock, is matched by several submerged rocks of similar shape in its vicinity. In Casco Bay the series of narrow islands and ledges is continued underwater. In southern New England farming is seriously interferred with by hundreds of bowlders, and the same formation, extending underwater, is a serious menace to navigation.

These obstructions often extend to within a few feet of the surface and can not be seen from a boat, so it is only by chance that they are found by an ordinary survey with lead and line. This can be readily understood by considering, as an analogy, a balloon drifting slowly over a town. The difficulty of dropping a weighted line so as to hit any particular small building, stack, or telegraph pole is obvious, and these are clearly visible. The hydrographer is entirely in the dark, his only advantage being that he is working in a more stable medium with a definite surface.

In wire-drag work, as will be explained hereafter, the wire, catching on a shoal, gives assurance that an obstruction exists and also gives its approximate location. In spite of this, it is sometimes necessary to sound, with lead and line, for a considerable length of time before the lead rests on the top of the shoal and the least depth is found. The improbability of hitting an obstruction of this nature with a lead thrown from a moving vessel is evident.

All the original surveys of the Atlantic coast were made under the necessity of covering as much area as possible in a given time. This made it necessary to run lines, usually parallel, with considerable distance between them, and to trust to special examinations of "indications" (shoal soundings occurring between those of greater depth) for the discovery of shoals. The surveys were, so far as possible, supplemented by local information. Local pilots and captains

of coasting vessels often have information as to the character of the bottom and the existence of uncharted shoals. Fishermen usually have a store of similar knowledge, for in setting trawls, lobster pots, and other fishing gear they are certain to find many rocks and ledges for which they have more or less accurate locations by ranges. Many of the fishermen live on outlying islands from which they can see breakers that may occur on the shoals only in the heaviest gales. Valuable information was obtained from all of these men, but it is hard to get comprehensive results in this manner without an unwarranted expenditure of time and money. There is a strong tendency to withhold such information, as an exclusive knowledge of rocky shoals is valuable to a fisherman because fish are found in greatest number in such places. Most of the data is not sufficiently accurate, and, in order to make use of it, the informant must be present because the system of describing ranges is such that they are usually very hard to locate. Many of the fishermen live in places inconvenient to reach and are at sea usually only during the dark hours of the early morning, so it is evident that this source of information has its limitations. Occasionally entirely erroneous information is received which probably has originated from attempts by seafaring men to outdo each other in yarns.

It is therefore evident that, after these surveys were completed, in spite of the most painstaking work, supplemented by local information, a large number of pinnacle rocks, sharp ledges, and bowlders remained undiscovered.

The most certain and practically the only way to find these obstructions in the past has been to strike them with a vessel. This, of course, is most expensive, and may result in heavy loss of life and property. The larger the vessel the greater the loss, because of the momentum with which it strikes, the expense of docking, and the greater value of the time lost. Many times the expense of adequate surveys has been lost in this manner.

We must also consider the fact that, in the days of the early surveys, the draft of vessels was small and the possibility of the present great drafts was not even recognized.[1] The extent of a 30-foot shoal was of slight importance then, while now this knowledge may be highly valuable.

As the draft of vessels increased and evidence as to the existence of uncharted dangers to navigation accumulated, it became more and more necessary to devise some method whereby all of these dangers could be located and the maximum safe depths of channels ascertained. A wire drag had been used on the Great Lakes and elsewhere for these purposes, and the apparatus was selected by the Coast Survey for experimentation. It has been adapted for ocean work and gradually perfected, until at the present time it is an apparatus, and the only apparatus, which makes it possible to resurvey a region and, at the conclusion of the survey, to state definitely the locations of all obstructions and what areas are free from obstructions.

It is not intended to give a detailed description of the apparatus and methods, as this is available for those interested in a number of sources. (See Special Publication No. 21, Department of Commerce, Coast and Geodetic Survey.)

The photograph of the model of the drag prepared for the Panama-Pacific Exposition gives an excellent idea of the construction of the apparatus and the method of operation. It will suffice to say that the horizontal member consists of wire and the verticals of chain and flexible cable at the large and small buoys, respectively. It may be stated that the purpose of the entire equipment is to place the horizontal member, or bottom wire, at the right place and depth at the right time to insure that it catches on all the obstructions that it meets and to make it possible to remove it from the obstructions in a reasonable time. Nearly all the natural forces encountered work against the first-named requirement, and this fact more than any other accounts for the long delay in adopting and perfecting the apparatus. Perhaps the best way to arrive at a correct understanding of the improvements and changes that have been made is to enumerate the difficulties encountered and to state how they were solved.

When this work was begun on the coast under the present system, in 1906, work had been done in deep water with light launches and outfit; but there had been no necessity to solve

[1] In the early days of the Maine surveys an officer reported that it would soon be necessary to make more detailed surveys, as the draft of vessels was likely to exceed 18 feet. The draft of some of the present-day vessels exceeds 35 feet.

the fundamental problems involved in shoal-water surveys. The first requirement was a means of knowing at exactly what distance below the surface the bottom wire was sweeping. This was determined by finding at what depth the wire struck a lead line held at rest from a small boat waiting in advance of the drag. The real difficulty, and one which still causes delay and expense, is to pass the wire close enough to the bottom to be sure of not missing any uncharted obstructions and at the same time to keep it from catching on those that are already known, as in the latter case time will be lost without obtaining useful information. To accomplish this, it is necessary to know the depth of the bottom wire not only at the points supported by the buoys but along every foot of its length. The weight of the wire (500 pounds to the mile) is appreciable and great enough to overcome the effect of the tension caused by the towing boats. This tension, of course, does not act at all when the drag is at rest. This weight causes the wire to sag between the buoys, the tendency to sag increasing as the tension decreases. At first, to overcome this sagging, the buoys were placed close together; but it was found that they caused so much resistance that a long drag could not be towed through the water. The problem was finally solved by the use of cedar floats attached to the wire at certain intervals between the buoys. These floats serve to balance the weight of the wire, and the buoys can be placed far enough apart to keep their number within reasonable limits.

The great difference between coast wire-drag work and similar work on the Great Lakes is in the tidal range. It is evident that unless provision is made for adjusting the length of the uprights connecting the buoys and the bottom wire the wire will soon be too far from the bottom with a rising tide or will rest on it with a falling tide, thereby stopping the progress of the drag. This condition was met by installing suitable drums on the buoys, which can be turned from small boats as required. This makes it possible to change the depth of the bottom wire to conform either to the state of the tide or to pass over shoals. Setting these uprights at different depths throughout the drag also makes it possible to match the contour of the bottom, and accordingly to use a much longer drag in bottom of varying depths than would otherwise be possible.

As the length of the drag was increased the labor of setting out, taking up, and controlling became so great that it became necessary to devise labor and time-saving machinery. An apparatus for taking up the drag was designed. This includes a 2-speed reel and a leader and tightener which, operated by an automatic winder, places the wire tightly and uniformly on the reel. The motive power for the apparatus is a 5-horsepower gasoline engine. Special small sinkers, which can be readily attached and detached, were devised. The small buoys were designed so as to have a slight resistance in passing through the water, thereby increasing the speed of the drag. A method of signaling, permitting an instantaneous exchange of signals, was perfected. By the standardization of methods and the use of a large tender, the operation of clearing the wire from a shoal which formerly required hours is now often accomplished in 10 or 15 minutes.

METHODS OF PROCEDURE AND IMPORTANCE OF WIRE-DRAG WORK.

The photograph of the wire-drag model indicates the method of finding shoals. It may be stated that the procedure is invariably the same, even if the particular methods used in clearing the drag may vary. Before the wire strikes a shoal it is clear that the launches must tow at an angle away from each other in order to produce tension on the wire. This angle varies in practice from 20° to 90° from the direction of progress. The launches rarely head in the direction that the drag is proceeding; but as long as they head at any angle, except directly away from each other, they will make progress. Even in the latter case the drag may be carried along by the current. Every effort is made to take advantage of the current, as the slow motion of the drag makes it impossible to proceed against a strong current. It requires skill and experience to keep the launches on a definite line, but the principle is that of a boat trying to go in a certain direction and heading at an angle from that direction to allow for current. In operating the drag, however, the relative effects of currents, wind against

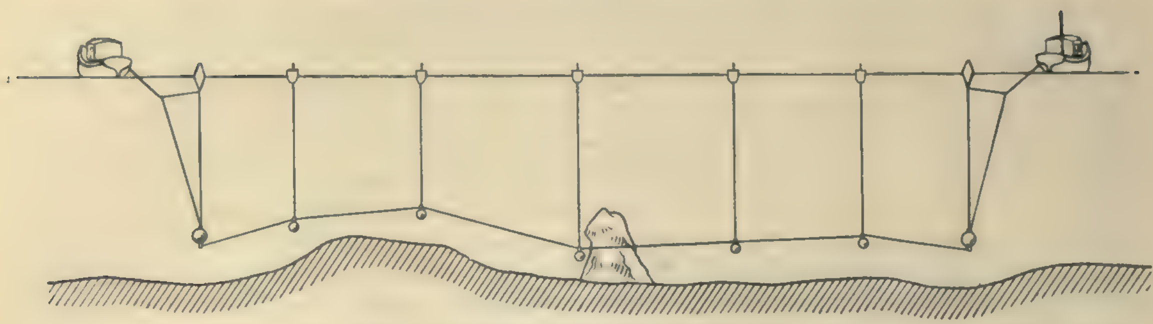

FIG. 1.—DRAG SET AT DIFFERENT DEPTHS.

FIG. 2.P—LAN OF DRAG UNDER WAY.

FIG. 3.—PLAN OF DRAG AGROUND.

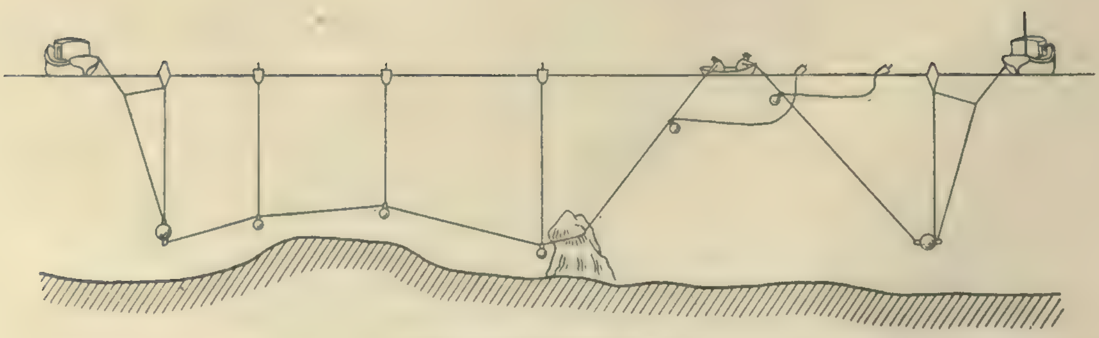

FIG. 4.—CLEARING DRAG.

the boat, and the tension of the drag at an angle to the direction of progress all make it more difficult to judge this allowance than on a fast-moving vessel.

The drag parts have all been designed for the heaviest strains that may come upon them plus a margin of safety. There is, for example, no danger of parting the bottom wire no matter how hard the launches pull nor at what angle. There is some difficulty, however, in getting materials that will meet all the conditions, and in some cases it is necessary to replace equipment oftener than would be necessary if materials with exactly the right qualities were available. As an example of the effectiveness of this part of the work, 15 separate shoals were found in a single day near Key West, Fla. This means that the drag proceeded at the beginning of the day until a shoal was found; then the drag was removed and proceeded 14 additional times.

The wire at times takes a surprisingly firm hold on rocks. Frequently it must be cut and a portion of it abandoned. Sometimes in soft rock, like coral, pieces of the rock will be broken off, and the wire has been known to twist itself around a heavy anchor, so that the anchor could be brought to the surface.

The various methods of clearing the drag are interesting. If firmly caught, the slack wire is taken on the tender and made fast. The tender then starts ahead at full speed, and when the tension comes on the wire the bow is pulled down a foot or more and the boat looks as if it were about to dive. It is then stopped, the slack wire gained is taken in, and the process is repeated. It is often necessary to make complete circles around the point where the wire is caught, and skill is required to keep the slack wire out of the propeller. Frequently the drag is cleared when it seems at first impossible to gain an inch.

It might at first thought seem necessary to place buoys, either temporary or permanent, on the rocks found or to destroy the rocks by blasting. This, however, is necessary only in the case of shoals of dangerous depth in important harbors and channels, and these shoals form a very small part of the total number discovered. The average navigator is capable, under all ordinary conditions, of avoiding shoals that are shown on the chart, and learning to do this is an essential part of his education.

At the end of each field season the charts affected are corrected at Washington for all changes that have been found during the season, a new plate being prepared if there are sufficient changes. This of course requires time, and it is necessary to acquaint mariners as soon as possible with dangers to navigation discovered. Where the shoals are of importance, their discovery is promptly reported by the officer in charge of the field work, and they are placed on the chart at once and described in the Weekly Notice to Mariners, which is available for all mariners desiring it. Dangerous shoals are usually buoyed without delay by the Bureau of Lighthouses, but the number of such buoys is limited to important dangers because of the expense of installing and maintaining buoys and other aids to navigation. It is not even necessary to mark shoals temporarily in order that they may be found again. Accurate positions are recorded and are available at any time. With practice the exact location can be found from the recorded angles. If it is desired to find a small pinnacle, for the purpose of blowing it up, the position is known and a very short improvised drag will suffice to find it at once.

There are many reasons why it is important that the charts should show all the dangers to navigation. Many vessels keep very close to the same courses when constantly navigating a region, but it must be remembered that there is no requirement that vessels shall follow beaten tracks. A vessel may go in any place where the charts show sufficient water, and the navigator can not be held responsible if he strikes an uncharted rock. Very often strangers will be off their reckoning when running in a fog. If a chart appears clear they will take a chance and continue on their course, while if dangers are shown they will anchor until it clears. There is no means of estimating how many vessels are saved from disaster on a dangerous shoal because the shoal is located on the chart. Furthermore navigators are accustomed to pass all dangers at a safe distance. If a danger is uncharted, a vessel in the act of avoiding a charted danger may strike it, for shoals often occur in groups.

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The legal status of the charts, in settling the responsibility for the grounding of vessels, is an important matter. In every such case an investigation is made by the steamboat inspectors, or, in case of naval vessels, a court of inquiry is held. If negligence is proved, the penalty may be so severe as to suspend or withdraw the license, and with it practically the means of livelihood of the offending master or pilot. There are corresponding penalties in the Navy. Of course, if a shoal is uncharted there is no blame or penalty. In all doubtful cases where the vessel, though damaged, succeeds in getting off before the facts can be ascertained by the proper authority, the claim that a rock is uncharted may be made or, what amounts to the same thing, a wrong location of the accident may be given. As the whole purpose of licensing navigators is to protect the safety and interests of the traveling and shipping public, it is important that the plea of an uncharted rock should everywhere be made untenable. Even under present conditions the wire drag is a valuable agent for settling such questions, as any such claim can be proved or disproved beyond all doubt by its use.

A correct chart is an excellent insurance on battleships, and one to which they are entitled. Furthermore insurance for commercial vessels is sufficiently high, and it is unfair both to the insurance companies and to those paying the premiums that an uncharted danger should exist.

In regions where pinnacles exist and the charted depths are not great, it is dangerous for submarines to operate beneath the surface. While this danger can not by present means be eliminated entirely on a coast such as that of New England, it is useful to know where depths of 48 feet are safe.

The Government annually spends considerable sums in deepening harbors and the channels approaching them. All such improvements begin at the point to which the charts indicate that the desired depth can be safely brought, and in the past it has been assumed that this was a perfectly safe and satisfactory practice. Occasionally improvements are made in harbors even before the approaching channels are deepened. In some harbors, where the tide range is great, vessels will use certain channels only at high tide, usually anchoring at the entrance until the tide is sufficiently high. This of course applies to the deepest-draft vessels entering the port. It is accordingly often important that there should be more water in the approaches to a harbor than in the entrance channels, so that the former may be freely navigated at the very lowest tides. It is evident that it is only proper to spend a comparatively small additional sum for wire-drag work to insure the usefulness of the expenditure of the great sums spent in harbor improvements in the principal ports.

Ports are often affected unfavorably by the grounding of vessels, no matter what the cause, and commerce may be driven to other places.

Of almost equal importance to showing all the dangers on the charts is the assurance that a known safe depth exists over an area clear from obstruction. The depth of drag used during the 1914 season as a maximum for Portland, Me., was 48 feet at mean low water. This depth was adopted after considering the maximum draft, while at rest, of the largest liners afloat, and adding to this an allowance for increased draft while at full speed (the allowance being obtained from the best available sources of information), an allowance for abnormally low tides which occur during storms, and an allowance for the possible effects of ocean swell on a vessel. In dragging, the depth of the bottom wire below the surface may at times be as much as 60 feet, as an additional allowance is made for the possible effect of swell on the drag. The cost of the work increases with the depth of drag used, but the extra expense and all precautions are justified when we consider the fact that a serious accident, even to a small vessel and without loss of life, would cover the cost of years of wire-drag work. A fast-moving liner striking a pinnacle rock in just the right way would suffer the fate of the *Titanic*, no matter what precautions might be taken.

In selecting the outer limits which should at present be adopted for the immense area to be dragged, the best guide is a study of the geological features. In eastern Maine 25 fathoms is considered safe, and work is carried to that depth. In Casco Bay, where there are few pinnacle rocks, the 18-fathom curve was selected as the outer limit. In southern New England it

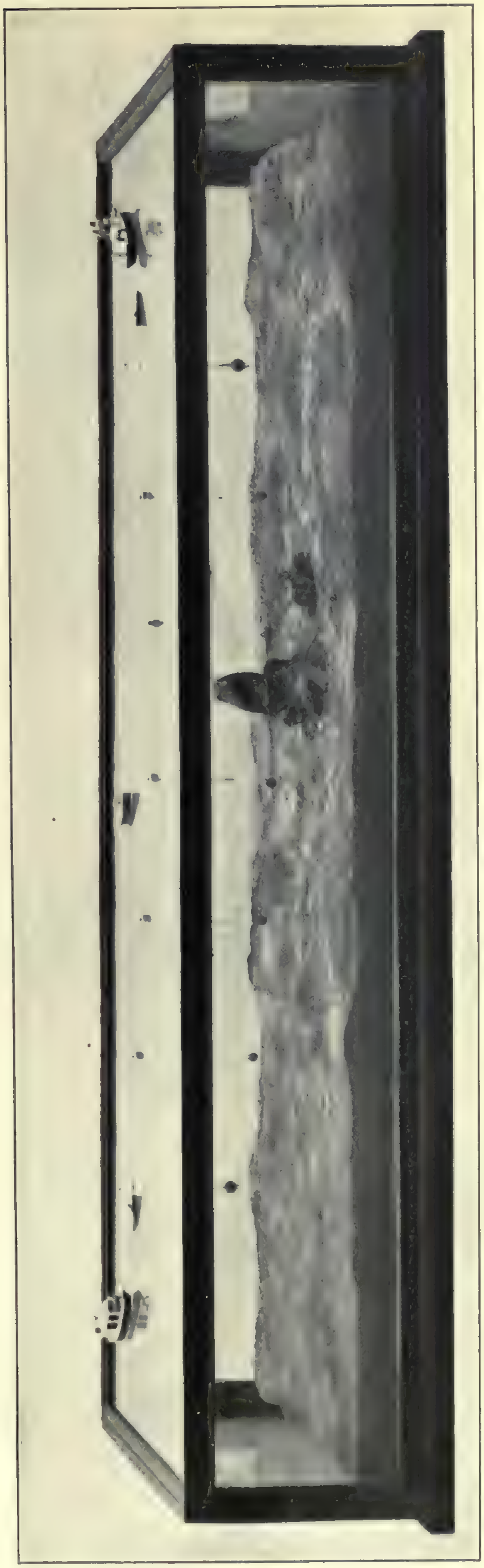

FIG. 5.—VIEW OF WIRE-DRAG MODEL.

is probable that few dangers would be found outside the 10-fathom curve, though eventually all work should be carried at least to the 15-fathom curve. This conclusion is based on the size of known bowlders.

The Coast Pilot, published to give directions to navigators, warns vessels not to pass over shoal areas even if the charted depths are considerably greater than the draft of the vessel. This is an excellent precaution to take under any circumstances.

Even in dragged areas, navigators should not attempt to scrape the bottom, for this practice is always dangerous except in carefully dredged channels where a stated depth is constantly maintained. It is difficult to pass the wire close to the bottom over every foot of the area, and possible uncertainties may occur in the last foot of depth indicated by the drag. There may be variations in the tides which can not be detected by the navigator, and a reasonable allowance must be made for the fact that the wire drag, although the best instrument available is in itself not absolutely infallible and that its efficiency depends on a large number of factors. All of these considerations call for the use of good judgment, but ordinarily there is no excuse, except stress of weather or difficulties of navigation, for grounding a vessel in an area that has been dragged.

Two questions frequently asked have an important bearing on the future value of wire-drag surveys made at the present time: Does the bottom change, and Do rocks change their depths? On the sandy portions of the coast changes of more or less importance constantly occur. Islands wash away and shoals disappear and appear in another place. Storms have been known to make channels and later to remove them. So far as the area covered by wire-drag work is concerned there is no reason to believe that the changes are appreciable except from a geological point of view. The shoals that are found are of ancient origin and are not likely to alter. It is possible that in places on the southern New England coast the bowlder groups are rearranged as the sand is washed from beneath them, but this would have a tendency to deepen the channels. In Florida there is a certain amount of coral growth, but probably most of the coral is dead or growing very slightly.

WIRE-DRAG WORK ACCOMPLISHED OR REQUIRED.

In discussing this subject the coast will be considered by localities.

While it would be desirable to take up a section of the coast and finish it before undertaking another, this has not been practicable. Except in 1914, there has been but one wire-drag party in the field. It has been necessary to take advantage of the favorable weather during the summer to do the exposed work on the open sea and to work in protected localities during the spring and fall. It has also been necessary to change the plans for the work frequently in order to meet special demands.

COAST OF NORTHERN NEW ENGLAND.

Eastport to Mount Desert Island.—No wire-drag work has been done in this region, but an examination of the chart shows that it will be necessary at some future time to investigate a considerable area. The approaches to Eastport and a part of Grand Manan Channel should be dragged. In the vicinity of Machias Seal Island and to the westward there are a large number of shoal indications, and the area between the mainland and the outer limits of these should be investigated. These indications extend to a distance of from 6 to 10 miles offshore. There are also a large number of bays, passages, and river entrances along the coast that should be dragged.

Mount Desert Island to Monhegan Island.—Considerable work has been done in this region, and the finished area includes Frenchmans Bay, all the shoal parts of Blue Hill Bay, the upper part of Jerico Bay, and East and West Penobscot Bays.

Large steamers and the largest schooners navigate the deeper waters, and great numbers of smaller commercial vessels, as well as pleasure yachts, frequent the whole region, especially during the summer season. The largest battleships, including those built for foreign nations,

use the Rockland naval trial course both before and after acceptance by the purchaser. This course has the special advantage of unusually deep water close to the shore. The important results of the work in this region serve to illustrate the need for wire-drag examinations not only in this area but along the greater part of the New England coast as well. Four shoals, on any one of which a battleship might have been seriously damaged, were found in the approach to the naval trial course. These shoals are now buoyed, but after their discovery and before they were marked by the Bureau of Lighthouses, the battleship *Arkansas*, while en route for her acceptance trials in charge of a local pilot, struck one of them. This could have been avoided by careful navigation, but such an occurrence, at a critical time, might have had disastrous consequences, and previous to their discovery other battleships must have passed very close to these obstructions. In addition to the danger to our vessels, the embarrassment of having such an accident happen to a foreign vessel is obvious.

Pinnacle rocks are common on the Maine coast, but as a general thing the action of ice and other agents has worn the rocks smooth, and as the depths rarely exceed 40 fathoms no such pinnacle rocks as occur in Alaska are found. For many years a charted depth of 20 fathoms was believed to be ample for all vessels; that is, when the general depth was 20 fathoms or over, it was considered that no rock could extend far enough above this to be a danger to navigation. In 1909, however, a 23-foot pinnacle rock was found in the main channel south of Vinal Haven Island, where the general depth is about 21 fathoms. At the time that this rock was being examined and located the battleship *Delaware* passed very close to the launches that were doing the work. Two channels that were believed to have ample depth were afterwards deepened by the United States Engineers when it was found that rocks existed with less depth on them than the draft of vessels regularly using the channels. The reason for such a condition being possible is that vessels usually follow the same course, with very slight variation, when regularly using a channel, and may pass close to a danger many times without striking it. Furthermore, all depths are referred to mean low water, and the depths on shoals may be ample except during the lower stages of the tide. A 14-foot shoal was found directly in the course of the steamers plying between Bangor and Boston. A channel buoy, indicating that vessels should pass close to it, was changed to a danger buoy to be avoided without changing its position. The lighthouse on Isle au Haut when built, in 1908, had a white sector covering the entire approach to the harbor, indicating a safe approach from any point where the light was visible. A few years later this sector was reduced to one-half its previous extent, because one-half the approach was found to be obstructed by shoals with a depth of from 16 to 18 feet. In the approach to Stonington, Me., near the entrance beacon, an 11-foot shoal was found where 9 fathoms had previously been charted. This was so small and abrupt that four attempts to pass a drag over it were made before the least depth was found. The masts of two vessels that had sunk in about 20 fathoms of water were found with 18 and 29 feet, respectively, over them. The former was destroyed by the United States Engineers as constituting a menace to navigation.

It will be necessary to examine a considerable area in this region in addition to that which has been dragged. Several small bays along the coast and the unfinished part of Blue Hill Bay should be dragged. The offshore work should be carried to the outer limit of the shoal indications, which extend on an average about 10 miles out from the mainland.

Monhegan Island to Casco Bay.—No wire-drag work has been done in this region. The bays along the coast and the Sheepscot and Kennebec Rivers require examination. The work should be carried an average distance of about 7 miles offshore, beyond which there are no shoal indications.

Casco Bay.—The outer part of this bay, including the principal approaches to Portland, has been completed. The people of Maine take pride in the harbor of Portland, which is considered the deepest natural harbor on the coast. The wire-drag examination resulted in the finding of a large number of long narrow ridges, extending nearly across the principal channels. No depths that would be dangerous to the majority of vessels were found, but a considerable

FIG. 6.—ROCKY COAST.

number of soundings less than the dredged depth of Portland Harbor were obtained. Of several channels previously indicated, only one was found safe for the deepest-draft vessels. One channel, which local shipping interests desired to adopt in order to get a straighter course into the harbor, was found to be blocked by a shoal in the middle. An extensive shoal area which lies across the southern end of the bay was found to have less depth than charted over almost its entire extent, but the channels between the parts of this shoal bank were proved to be free from obstructions. Portland is the principal winter terminal of the Grand Trunk Railroad, and large vessels, such as the *Carmania,* enter the harbor during the winter season, when the greatest seas are encountered, and the danger of grounding is therefore greater.

In addition to the work that has been done, the large number of bays and river entrances that form the inner part of Casco Bay should be investigated.

Casco Bay to Cape Ann.—No work has been done along this part of the coast. A large number of shoal indications appear on the chart and it will be necessary to examine all the area along this coast out to the limits of the shoal indications, which extend about 10 miles offshore. The indications are especially numerous in the vicinity of Portsmouth, which is likely to be frequented by the largest battleships.

Boston Bay.—No work has been done in this region. In this locality the rock formation begins to give way to bowlders and, as it is north of the terminal moraine, the bowlders are scattered. An examination of the chart shows that about 300 square miles of area lie between the 20-fathom curve and the dredged channels into Boston Harbor. In some cases 7 fathoms or less are indicated not far from the approach to the dredged channels. This is accordingly the most important wire-drag work to be done. Boston is among the most active of American ports in making harbor improvements, and a project for a large dry dock suitable for the largest vessels afloat is under consideration. This will eventually attract such vessels to Boston and the contingency should be provided for by making the approaches absolutely safe. It will also be necessary to investigate Stellwagen Bank at some future time.

Cape Cod Bay.—This area is of importance, as the approach to the Cape Cod Canal and its survey is really a continuation of the work in Buzzards Bay, with the same claim to importance. Portions of the area are in especial need of work and other parts may well be reserved till later.

Cape Cod Shoals and Nantucket Sound.—The rock and bowlder formations are infrequent in this region, which needs no dangers from unchartered rocks to make it one of the most dreaded localities on the Atlantic coast. It may be necessary at some future time to use the wire drag to locate narrow sand ridges in this region, but the apparatus is not well adapted to this kind of work, though it can be so used.

COAST OF SOUTHERN NEW ENGLAND.

Shoals and pinnacle rocks are far less frequent in this part of the coast than in northern New England. The characteristic feature from Cape Cod to New York is the presence of groups of bowlders or isolated bowlders in immense numbers, as the terminal moraine of the glacial age corresponds nearly with the coast line. Some of the fields in southern Rhode Island and southeastern Connecticut are so filled with bowlders that there is scarcely room for an animal to graze. It is almost impossible to believe that the underwater areas can be more thickly bowlder strewn, but the washing away of the loose material between the bowlders by the current may make this true.

Buzzards Bay and Vineyard Sound.—The dragging of Buzzards Bay is nearly completed. As the approach to New Bedford and the Cape Cod Canal, the resurvey of this bay was considered of great immediate importance. Many dangerous shoals were found among the hundreds of uncharted shoals, especially in the western approach, where two shoals of less depth than in the dredged channel to New Bedford and in the Cape Cod Canal were found in the direct approach to the lightship marking the channel. It is now possible for vessels to use any part of the bay with safety, and naval maneuvers can be carried on without risk to the vessels. In 1904 the cruiser *Brooklyn* struck a bowlder in New Bedford Harbor and was badly damaged,

but the danger of such an occurrence has been removed. It is in such areas as this that the greatest care must be exercised to insure that the drag does not jump over bowlders. These are generally smooth and rounded and if the drag wire strikes above their center there is a tendency to slip over. With proper care this will not occur without some evidence, but watchfulness is necessary.

Quicks Hole and the adjacent part of Vineyard Sound have the same formation as Buzzards Bay. They have not yet been dragged, but should be as soon as practicable.

Narragansett Bay.—Only fragmentary work has been done in this bay. A recent resurvey by ordinary hydrographic methods only emphasizes the need of wire-drag work. This bay is important as the approach to Providence and Fall River and as the most important rendezvous of naval vessels on the north Atlantic coast.

Block Island Sound, Gardiners Bay, and Peconic Bays.—About two-thirds of the shoal ridge connecting Long and Block Islands has been dragged and the dangers located. This region is of no great importance except as the approach to the proposed harbor at Montauk Point, which has been considered as a means of reducing the congestion of the port of New York. The project has not been carried out, and its serious consideration depends largely upon whether a safe channel for the largest liners exists. It is interesting to note that the last time this channel was used for trans-Atlantic liners the *Great Eastern* struck a rock which still bears her name. The dragging of this region proved that drag work could be successfully prosecuted in regions of strong currents in the open sea. Launches of 65 feet were first successfully used, the previous boats not averaging more than 40 feet. The hazy atmosphere that is a characteristic accompaniment of the prevailing southwesterly winds of the summer time made it necessary to use buoys for signals.

A wreck was found in the deepest part of this channel with the mast only 6 feet below the surface and the boom actually projecting above the water and resembling a spar buoy. This was promptly removed by a revenue cutter.

Along the north shore of Block Island Sound there is a bowlder-strewn area at least a mile wide which vessels have been warned to avoid until the area has been completely dragged. It was here that the battleship *Nebraska* struck a group of bowlders in 1913. So many bowlder patches were found during the wire-drag examination that followed that it was necessary to designate this area for a future complete resurvey.

Gardiners Bay is used for torpedo-boat maneuvers. One channel between this bay and Long Island Sound was examined and a number of unexpected bowlders were found. This and Peconic Bays will have to be dragged eventually to make them absolutely safe.

Fishers Island Sound.—Sugar Reef Passage only has been dragged. This sound not only has bowlder bottom but many narrow ridges. While vessels of great draft do not pass through, many yachts use it. The strong currents make it important to know the extent of the safe channels.

Long Island Sound.—Not only the doubtful part (which includes a considerable area in the eastern part), the entire western quarter, and the whole north shore, but the whole Sound should be dragged. The deeper parts can be rapidly dragged with a long drag and then certainty as to the depths is assured. Recent reexaminations of the western part of the Sound have resulted in finding many shoals by means of the lead alone. Only fragmentary wire-drag work has been done. The harbor of refuge at Duck Island and its approaches, some shoal areas in the Sound to the south of this, and the area between City and Hart Islands near New York are the only portions that have been examined, but in each case uncharted shoals were found.

Between New York and Florida the amount of wire-drag work likely to be required is relatively small, as the shores are sandy and on the Atlantic Coastal Plain there is very little rock. There are, however, kettle bottoms and oyster rocks in Chesapeake Bay and the Potomac River. In the southern sounds and rivers are stump-infested areas and also oyster rocks.

Florida Reefs.—This is the only coral formation on the coast of the United States. For a distance of about 220 miles there is a practically continuous reef along the northern edge of

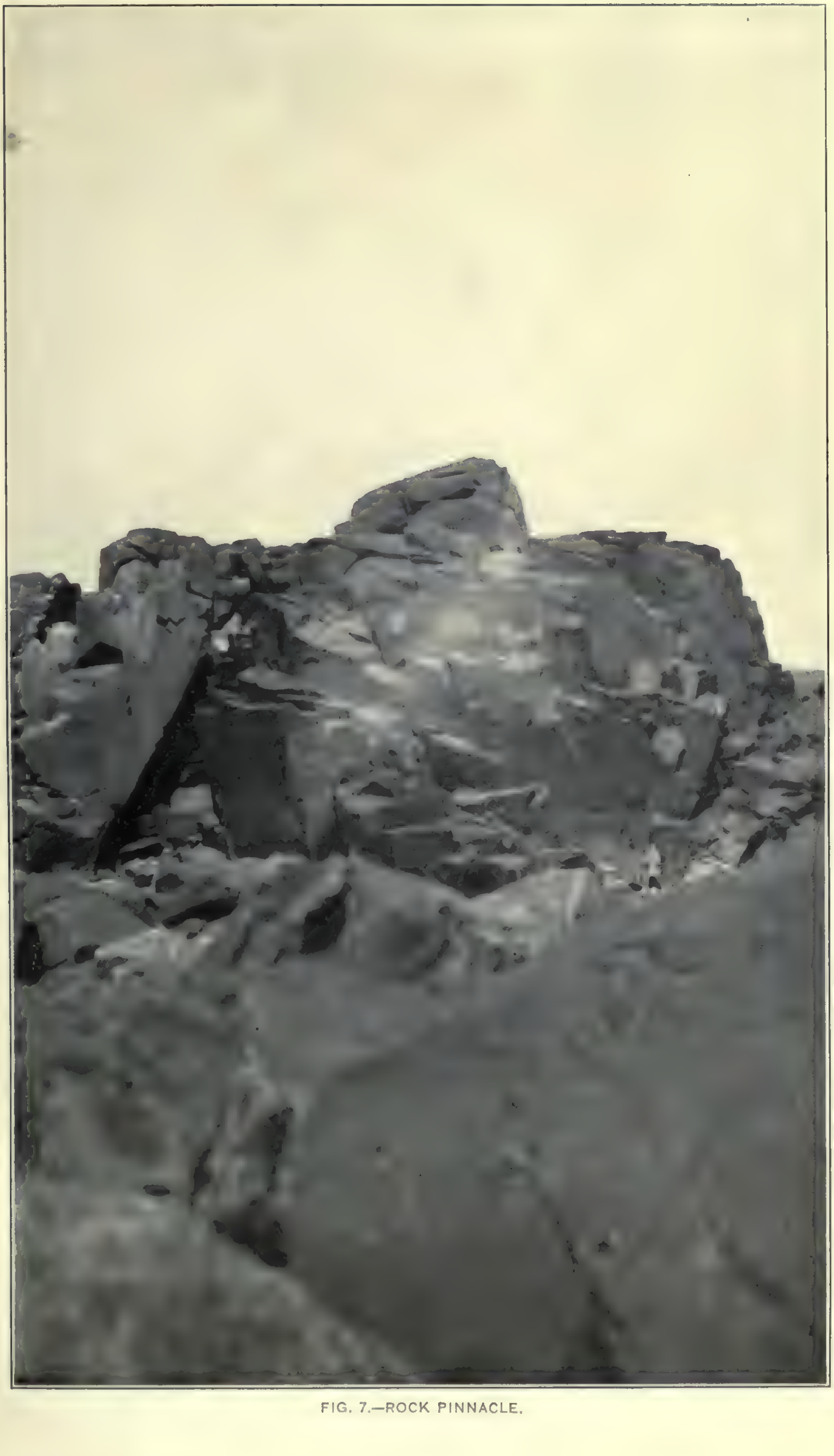

FIG. 7.—ROCK PINNACLE.

the Straits of Florida. Between this reef and the Florida Keys there are either continuous lines of reefs and coral heads or isolated heads with channels between. There is no area between the Straits of Florida and the Keys, or in the deeper channels between the Keys from Miami to Dry Tortugas and to the deep water outside the shoal bank lying west of Tortugas, that can be considered absolutely safe, except the 65 square miles of dragged area in the vicinity of Key West.

An important fact is that the line of reef along the edge of the straits is marked at frequent intervals by beacons and lighthouses. It was originally believed that the deep water of the Gulf Stream came close to the reefs and that deep-draft vessels could pass close to them. The discovery of a series of secondary reefs or narrow ridges lying one-half to three-quarters of a mile outside indicates that this practice is dangerous. These reefs rise to dangerous heights only at intervals, but they have been examined only for a distance of 22 miles in the vicinity of Key West. There is every reason to believe that shoal spots exist at intervals throughout the extent of the reefs. This is a really important matter, as to avoid the strong easterly current of the Gulf Stream vessels bound west are tempted by the desire to save time and coal to pass dangerously close to the reefs, where the current is much weaker and sometimes even reversed.

As stated above the only wire-drag work in this region has been done in the vicinity of Key West. This port has probably the deepest natural harbor south of Hampton Roads, and during the Spanish-American War it was of great naval importance. In addition to its use as a coaling and repair station many of the captured prizes were anchored there pending the action of the courts. The steamer *Denver* of the Mallory Steamship Co., recently lost at sea, formerly entered Key West with a draft of 24 feet.

The results at Key West are startling to anyone not familiar with the coral formation. Immediately after the Spanish-American War very thorough surveys by means of the lead line were begun. In such an area as that at Key West these are practically useless except as furnishing the basis for wire-drag work, as they are absolutely inconclusive. As the result of dragging, over 500 coral heads and shoals were found in the 65 square miles dragged. In the principal channel, supposed to have 30 feet, four 17 to 24 foot shoals were found, which were promptly removed by the United States engineers. This channel was found to have only 28 feet in its entrance instead of 30 feet, and this was narrowed by shoals on each side. The information obtained with the drag was necessary for the deepening of the channel, which has since been done.

Of the four important and three unimportant channels remaining, all have been practically abandoned except the Northwest Channel. This is partly dredged but it was found difficult to carry the depth through the main channel which can be taken through the dredged portion. The Southeast Channel, originally used by vessels 17 feet in draft, was found to have a number of 13-foot heads, and the buoys have been removed.

It has been necessary to drag areas at Key West which are of no commercial importance, as the maneuvers of the torpedo flotillas are held here every winter. The destroyers require a comparatively shoal area, so that lost torpedoes may be recovered, while the destroyers must be in no danger of striking shoals, as at their high speed such an occurrence would be fatal.

Between Dry Tortugas and the Keys to the eastward there is a channel much used by vessels bound to the east Gulf ports. This channel has two charted shoals in the middle, one of which is marked by Rebecca Shoal Light, and there is every reason to believe that there are many more. Several vessels have reported striking in the vicinity, but owing to uncertainty in their positions the facts can be determined only by an extensive wire-drag survey.

Vessels which are doubtful about this channel and decide to pass west of Tortugas must give the latter a wide berth, as there is a shoal bank west of Tortugas. This bank must also be avoided by vessels approaching from the westward.

These open-sea areas remote from harbors present special difficulties in the use of the wire drag, but it is practicable to do the work. The expense will be high and it will be necessary to confine the work to the portions used either by commercial vessels or by the Navy.

UNIT COST OF WIRE-DRAG WORK.

This is a complex matter. Wire-drag work consists of two antagonistic operations—that of covering area, or sweeping, and that of finding shoals. The apparatus best adapted to the first operation is not that which is most effective in the second, and that actually used is a compromise between the two requirements. Covering area proceeds most rapidly when the shoals are few in number, and shoals can be located and developed most satisfactorily when the purpose of covering area rapidly is temporarily subordinated.

The actual cost of wire-drag work in the past has varied through a wide range from between $125 and $175 per square mile on the New England coast to between $450 and $600 in the vicinity of Key West. It is proposed to analyze the cost in such a way that it will be evident why the costs are so large and why they vary so much.

The principal factors that increase the cost will be listed more completely later; they include weather, tides, currents, bottom conditions, interference from the operations of fishermen, failure of equipment, and lack of skill on part of members of party.

It may be said with reference to very expensive work that usually the very factors that increase the cost of the work are those that make navigation dangerous, and that usually if the work is more costly the results are likewise of greater value.

The following method of analyzing unit cost has been adopted: The statute square mile has been adopted as the unit of area. The cost per unit of area will be considered without effort to distinguish between cost of sweeping and cost of locating shoals.

In order to have a unit which will be practically common to all operations the *basic cost per linear mile* will be defined (b in formula). This is the cost of moving a drag 1 mile under conditions that are theoretically possible but which are rarely if ever obtained. It is the cost of operating through a linear mile a drag of such length as to cover a statute mile at a single sweep, moving at the rate of 1.5 statute miles per hour for five hours each day, every day except Sundays and legal holidays, from the first day's dragging to the last day of the season. This unit cost can be obtained by dividing the total cost of the season's work (C) by the total number of days just mentioned (t') and then by $7.5 = v' \times d'$. This will be very nearly the same on the coast of New England as on the coast of Florida and will differ from that in Alaska only with the increased total cost. It will be slightly less for a long season than for a short one, as transportation and other charges that are not monthly are relatively smaller. For a carefully analyzed season at Portland, Me., the value of b was about $16. It is evident that it will cost just as much to operate a 1,200-foot drag as a 4,000-foot drag, provided the velocity is the same.

Now, in order to reach the desired unit cost per square mile from this basic cost per linear mile it is necessary to multiply the latter by certain factors.

The first factor, L, is obtained by dividing the number of linear miles (l') by the area (A). It is evident that if four linear miles are required for each square mile finished, the cost will be four times as great as when only one mile is required. This factor includes the drag length, the overlap whether necessary or excessive, and repetition whether because of shoals or area missed.

The second factor, V, is obtained by dividing the standard velocity, 1.5 (v') miles per hour, by the actual velocity (v). The necessary increase or decrease due to this factor is obvious.

The third factor, D, is obtained by dividing the number of days, exclusive of Sundays and legal holidays, from the first day of dragging to the last (d') by the actual number of days on which work was done during this period (d). This is the weather factor and includes the effects of wind, sea, swell, and conditions which make signals invisible, such as fog, haze, and smoke. The amount of exposure to the open sea enters into this, as work can be done in protected regions when impracticable in the open sea. The factor decreases with the ability of the boats.

FIG. 8.—BOWLDER FORMATION.

The fourth factor, T, is obtained by dividing the standard day, five hours (t'), by the actual time spent in dragging (t). This takes into account time lost from dragging for every cause except running to and from the harbor, setting out and taking up the drag, and bad weather, and includes time usefully spent in locating shoals as well as that lost through drag failure or failure of the engines. It is not an efficiency factor directly, as much of the time lost from dragging may be useful in other ways. The standard day of five hours represents about the best average that is possible under Atlantic coast conditions, and takes into account the relation of the working area to the base or bases and high efficiency in setting out and taking up the drag.

Then the product $b \times L \times V \times D \times T$ equals c, the *cost per square mile*. A little study will show that the numerators and denominators of the various factors cancel out until total cost divided by area is left, as should be the case.

$\frac{C}{t'\,v'\,d'}\,\frac{l'}{A}\,\frac{v'}{v}\,\frac{d'}{d}\,\frac{t'}{t}=\frac{C\,l'}{A\,v\,d\,t}$. It is clear that $v\,d\,t$ is the number of actual linear miles and equals l'.

It is evident from the above discussion that time is the one important factor in wire-drag work. On the Atlantic coast there is no division of labor, as the party does no other work except wire-drag work.

Now, what is the usefulness of this method? The real test is whether a private bidder could use it as a basis for a bid for work to be done in a given locality. It is claimed that this could be done provided that he understood the method and had data from previous seasons (nearly all satisfactory bidding is based on knowledge of conditions), and provided that he could be granted the authority possessed only by the Government to require the removal of lobster pots (without which he could not bid at any price) and an understanding of the amount of time likely to be lost on this account.

In order to get the value of the constants it is necessary to make a very careful analysis of a season's work. The 1914 season at Portland, Me., has been selected, as it was a long season under about average conditions, though the unit cost was higher than usual because of the great number of shoals found. There was a fair proportion of open area, but not so great as may be generally expected on the coast of New England. The records were kept in such a way that a complete analysis could be made. The period of dragging extended from May 7 to September 28. The party arrived in the field on April 20 and left the field on September 30. In this case t' equaled 123; t equaled 80, 30 before June 30 and 50 after. The total cost was $14,820. Of this, 56 per cent represented pay and subsistence of party; 23 per cent, the cost of launches and fuel (engineers included in party); 2 per cent, incidentals, such as rental, signal building, storage, etc.; 2 per cent, traveling expense; 14 per cent, net supplies used; 3 per cent, depreciation in outfit. About one-third of the cost of supplies was for improvements, which have since paid for themselves in results. The first item, pay and subsistence, was unusually large because during May and June a large number of inexperienced officers were attached to the party to get some knowledge of the work before proceeding to other parties.

During this season 85 square miles of area were dragged, 22 before June 30 and 63 after that date.

Average time occupied.

	Hrs.	mns.		Hrs.	mns.
Run to working grounds	1	16	Return from working grounds	1	08
Setting out drag		42	Taking up drag		36
Spent in dragging	2	12	On shoals	1	27
Parted drag, dead lines		47	Lobster pots		24
Drag day	4	51	Total day	[1] 8	30

Number of separate soundings, 280, per square mile, 3.3 (n); per day, 3.5.
Number of linear miles, 252; before June 30, 88; per day, 3.15.

[1] Of course, on many days more, on some days less, on account of weather

Analysis of unit cost.

	Entire season.	Before June 30.	July 1–Sept. 28.
b	15.9	15.9	15.9
L	2.96	4	2.6
V	1.05	.86	1.1
D	1.54	1.56	1.52
T	2.27	2.76	2.08
Product of 4 factors	10.85	14.9	9.05
C	$173	$240	$145
	n=3.3	n=6.3	n=2.2
Total cost	$14,800	[1] $5,280	[1] $9,150

[1] Discrepancy is unavoidable when so many factors are involved.

Comparison of two parts of season.

First part.—All area was very shoal. Charted ledges and buoys made it necessary to use a short drag. A very important area was examined with great care.

Second part.—More than half open area, but with shoals near the maximum depth; about one-third of the area very broken and ragged. New signal system permitted the use of a 4,000-foot drag in examining shoal areas.

For the sake of comparison the above season will be compared with two others:

Comparison with other seasons.

	Portland, 1914.	Key West, 1915.	Panama, 1912.
b	15.9	17	22
L	2.96	4.3	2
V	1.05	1.1	1
D	1.54	2	1.1
T	2.27	4	1.2
Product	10.85	37	2.6
C	$175.00	$667.00	$60.00
n	3.3	10	.2

In order to decrease the factors, it is evident that it is necessary to increase the time spent in dragging, the length of the drag, and the speed. There are serious objections or obstacles in the way of increasing each. The run to and from the working grounds with given launches is fixed, with advantages in having fast launches. The time of setting out and taking up the drag can be decreased little, as 35 minutes for a 4,000-foot drag sufficed for each operation through a period of several weeks. The removal of the drag from shoals was kept at the low figure of 26 minutes through an entire season. The losses from lobster pots have been reduced to the lowest possible figure. Losses through failure of drag are studied and every effort made to remedy the defects. Large launches make it possible to work in rougher seas and decrease the weather factor.

The length of drag is kept as great as possible, but a number of elements keep this down. In work close to bottom the time required for the tender or tenders to make a depth change fixes the length. The length of drag is often restricted by the width of the sections laid out for lobstermen to remove their pots. In narrow channels, or in regions obstructed by ledges or buoys, the drag length is obviously restricted.

The velocity in deep-water long-drag work could with advantage be greater than 1.5 miles per hour could enough power be used to gain this extra velocity. In shoal water a greater velocity is a serious disadvantage. The tenders can not make the changes in the drag depth fast enough either on approaching a shoal or in setting the drag deeper after passing it, and the area of doubtful depth is increased. At a high speed the likelihood of parting the wire when the drag strikes is greatly increased and there is danger that the drag will not catch firmly.

As to the repetition involved in factor L, it should be remembered that the effective width of the drag is important. This may be reduced, either by failure to keep the launches heading at sufficient angles to each other to get the required tension or by the end launch failing to keep the drag normal to the direction of progress. A curious feature is that the amount of repetition necessary does not increase directly with the number of shoals, but in a much smaller ratio, as when the shoals are closely grouped a single sweep may be sufficient to pass over them all.

It should be remembered that the cost of covering area has a more definite meaning than the cost of triangulation or ordinary hydrography. The wire is actually passed over an area, and no imaginary horizontal or vertical lines enter into the operation. In other words, the operation involves three dimensions instead of two, in that a definite volume of water is actually separated, so to speak.

Now, in the "Description of the Long Wire Drag" for 1914 it is stated that the unit cost of wire-drag work in New England is $125 per square mile. It would appear that the work at Portland represented a loss in economy. In spite of this there has been a steady increase in economy and the results for a given cost of work have increased.

1. The length of drag for each class of area has increased steadily. For example, at Portland the average length of drag in shoal-water work in the open sea was increased from 3,000 feet to 4,000 feet.

2. The time of the incidental operations has decreased.

3. The use of larger launches has made it possible to work in rougher water.

4. The improvement in labor-saving machinery has made it possible to reduce the number of men.

5. The operation of clearing the drag and connecting it when parted has been improved, with a consequent reduction of time.

6. The present system of obtaining removal of lobster pots is more effective, and larger sections can be laid out.

REASONS WHY THE COST HAS APPARENTLY INCREASED.

1. Since 1910 all work on the New England coast has been done in the open sea, or that in the bays has been done at an unfavorable season. This was not true previous to that time. There has been very little clear area and some of the area had an excessive number of uncharted shoals.

2. To meet the increased draft of vessels in the important ports whose approaches were being dragged the maximum depth of drag was increased from 36 to 48 feet, bringing large areas into the class to be dragged close to bottom as well as increasing the number found. It is very obvious that with shoals projecting the same height above the general surface of the bottom the closer the wire is passed to bottom the more will be found.

3. The use of large launches, which were necessary to make any progress, increased the cost nearly in proportion to the increased output.

4. The great amount of area dragged close to bottom requires a highly skilled force of men to get results commensurate with the expenditure, and pay must be according. Incidentally the work has been done almost exclusively from summer resorts, where there are practically no available men locally and the cost of living is exceptionally high. A long drag in open water with a few shoals can be operated with comparative ease, no matter if its length is more than 2 miles, while a short drag in shoal water often requires all of the ability of a highly skilled party to get any results at all.

It is thought that the increased efficiency and saving in cost will be very clearly shown during the present season at Boston. The conditions as to number of shoals and lobster pots, while by no means entirely favorable, are far better than at Portland.

To give an application of the method of analyzing the cost at the beginning of a season the area to be dragged by wire-drag party No. 1 will be analyzed.

There are about 60 square miles to be dragged with the proposed 24,000-foot drag operated jointly by parties No. 1 and No. 2. It is believed that this can be done successfully, as a 12,000-foot drag was operated at Panama with much inferior equipment. There are 45 addi-

tional square miles outside the 10-fathom curve which will permit the use of a 5,000-foot drag. There are about 45 square miles of shoal water area, about one-half of which is of difficult character. This will usually permit the use of a 3,500-foot drag.

	Section 1.	Section 2.	Section 3.
b	16	16	16
L	0.7	1.5	3.5
V	1.2	1.1	1
D	1.5	1.5	1.5
T	1.2	2	2.5
Product	1.67	5	13.1
C	$20	$80	$210
Total cost ($14,150)	$1,200	$3,600	$9,350

Assuming that the above program could be carried out the net unit cost would be $100 per square mile. It is proposed to analyze the cost by the above method at the close of each month.

SUMMARY OF CAUSES THAT INTERFERE WITH THE PROGRESS OF WIRE-DRAG WORK.

1. *Weather.*—(*a*) Wind; (*b*) sea; (*c*) swell; (*d*) fog; (*e*) haze; (*f*) smoke.

2. *Bottom conditions.*—(*a*) High percentage of area of a depth less than the maximum depth to be verified; (*b*) broken relief of bottom; (*c*) number of uncharted shoals found, total soundings minus those which are too close to others to be considered separate or of less than charted depth; (*d*) small size of shoals—hard to get lead on small pinnacles; (*e*) large size of shoals—difficult to find all points of such shoals and harder to clear drag.

3. *Current conditions.*—(*a*) Head tide reduces speed of drag; (*b*) cross tides make it difficult to control drag; (*c*) fair tide may make the drag go too fast for best results and drag may part if it catches bottom suddenly; (*d*) excessive currents may cause tide rips and so make it possible to work only during slack water; (*e*) current running against sea or swell make them much greater; (*f*) reversal of current with the tide usually makes it impossible to utilize a fair tide throughout the working day, sometimes more economical to stop work than to run against tide; (*g*) currents running contrary to expectation, often due to wind. As the effort is made to select favorable currents, opposite conditions if found have disastrous results in reducing the output of work.

4. *Tide conditions.*—(*a*) A great range makes it hard to keep the drag at the desired depth—tends to be too great on ebb, too small on flood; (*b*) when drag is aground or delayed for any reason falling tide may place all of drag aground instead of a part; (*c*) difference between actual and predicted tides may cause drag to catch or pass too far above shoals.

5. *Location.*—(*a*) Distance of harbor used as base from working grounds; (*b*) amount of exposure to sea and winds; (*c*) islands, ledges, etc., which make it necessary to shorten drag.

6. *Lobster pots and other fishing gear.*—(*a*) Cause delay in setting buoys for their removal; (*b*) make it necessary to shorten days when sections are completed.

7. *Lack of skill in party.*—(*a*) In keeping drag in desired position—may result in unsatisfactory results in depth, striking shoals or charted depths when not desired and in leaving "splits" which later require that time be spent in running over finished area to reach them or in taking up and setting out the drag several times in a day; (*b*) in keeping depth correct, especially in judging tide and speed of drag; (*c*) in properly predicting amount of wind, sea, and swell; (*d*) in finding shoals promptly; (*e*) in removing drag promptly after shoals are located; (*f*) in getting the parts of the drag together after the wire breaks; (*g*) in keeping the drag parts out of the propellers; (*h*) in observations which may put in error the position of the launches or the shoals.

8. *Equipment and apparatus.*—(*a*) Breaking of the wire in setting out or when dragging; (*b*) failure of buoys; (*c*) failure of engines, eight in number. These include those propelling the launches engaged in towing, those on the tenders, and the auxiliary engines, operating anchor hoists, air compressor, reels. Failure of any of these may stop the work or delay it. These are all gasoline engines, which are perhaps more liable to get out of order than others.

DEPARTMENT OF COMMERCE
U. S. COAST AND GEODETIC SURVEY
Form 20 b

MONTHLY REPORT AND JOURNAL OF WIRE DRAG PARTY.

Party No. ________________, ____, **Chief of Party.**

______________________________, ______________________, *191*
(Place.) (Date.)

SIR:

The following report and journal for the month of ________________________ includes a statement of the progress of the wire drag party under my charge in execution of your instructions dated ________________

General locality of work ____

Date of arrival in field ________________________; of beginning dragging ________________________

Date of leaving field ________________________; of ending dragging ________________________

SUMMARY.

Days on which wire drag work was done (d) ________________

Days on which wire drag work was prevented by weather ______________; other causes ________________

Total days, exclusive of Sunday and legal holidays, after beginning or before ending dragging (d') ____________

Linear miles (l') ________________________; linear miles per day (l) ________________________

Soundings retained (n') ____________________; soundings retained per square mile ________________________

Mean time spent in dragging (t) ____

Mean time spent on shoals ____

Mean available part of working day (compared with standard effective day of 5 hrs.) ________________________

Area completed during month (A) ______________ sq. mi.; to end of last month ____________________ sq. mi.

Total area completed to date ______________ sq. mi.

	During month.	At end of last month.	At end of this month.
L			
V			
D			
T			
b			
C			
n			

Explanation: $L = l'/A$ $V = 1.5\ (l/t)$ $D = d'/d$ $T = 5/t$ $C = b \cdot L \cdot V \cdot D \cdot T$ b = total cost for entire season, including net cost of supplies used and depreciation divided by 7.5 d'.

SHORE WORK ON EQUIPMENT AND OFFICE WORK.

Shore work: 1. Wire. 2. Towlines. 3. Uprights. 4. Buoys. 5. Floats. 6. Reels. 7. Engines. 8. Signal outfit. 9. Improvements. 10. Lobster-pot buoys. 11. Putting fuel aboard. 12. Miscellaneous.

Office work: A. Records. B. Sheets. C. Reports. D. Accounts. E. Preparing sections of charts for various purposes. F. Description and drawing of apparatus. G. Instructions for members of party in performance of duty. H. Articles for publication. I. Lobster-pot notices. J. Correspondence. K. Bids for supplies. L. Miscellaneous.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Day of Month.	Weather and Sea Conditions.					Time Loss—			Time Spent in Daily Incidental Work.				
	Wind.		Surface Conditions.		Atmospheric Conditions.	Unavoidable.	Accidental.						
	Velocity.	Direction.	Sea.	Swell.		Bad Weather.	Drag Failure.	Engine Failure.	Run Out.	Set Out.	Take Up.	Run Back.	Total.
1													
2													
3													
4													
5													
6													
7													
8													
9													
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26													
27													
28													
29													
30													
31													
Total,													
Means.													

15	16	17	18	19	20	21	22	23	
TIME SPENT IN OCCASIONAL INCIDENTAL WORK.			TIME SPENT IN EFFECTIVE WORK.		Available part of working day.	RESULTS.			SHORE WORK ON DRAG—OFFICE WORK—REMARKS.
Dead Lines.	Lobster Pots.	Getting Supplies.	Dragging.	On Shoals.		Linear Miles.	Drag Length.	Retained Soundings.	

ORGANIZATION OF PARTY.

Names of Officers in Party.	Rank.	Persons in Party Exclusive of Chief.	Number.
		Assistants	
		Aids	
		Watch officers and mates	
		Deck officers	
		Hands	

COST.

	Paid During Month.	Incurred, Not Paid.	Total to End of Month.
Party expenses:			
Party pay			
Subsistence			
Launches			
Supplies			
Transportation			
Miscellaneous			
Pay of normal force			
Officers' pay roll			
Total			

Post office to which letters should be addressed ....

Address telegrams or telephone messages to ....

Address freight or express to ....

Respectfully,

....

Coast and Geodetic Survey, Chief of Party.

To the Superintendent
U. S. Coast and Geodetic Survey.

DIRECTIONS.

In Col. 2 enter miles per hour, if practicable. Col. 6 refers to visibility of signals, fog, haze, rain, etc. In Col. 7 estimate time lost by delay in start or early return due to weather. Col. 20 is sum of Cols. 8, 9, 15, 16, 17, 18, 19; it represents the part of each day when work is not interfered with by bad weather exclusive of time used in setting out and taking up drag—that is, the time that could be used in dragging were there no interruptions. Col. 23 means the actual number of uncharted shoals or soundings found. Those which plot very close to others, or which give no new information, are omitted.

It is advisable for the Chief of Party to fill out the journal personally each day, preferably directly from the record during the run to the harbor. In this way it will give valuable results. Various complications, such as time lost through the drag parting on shoals and other causes acting simultaneously, must be divided according to judgment.

In entering shore and office work use only the corresponding letters and figures given on page 1.